Parameters for Selection of Boilers

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SYNOPSIS

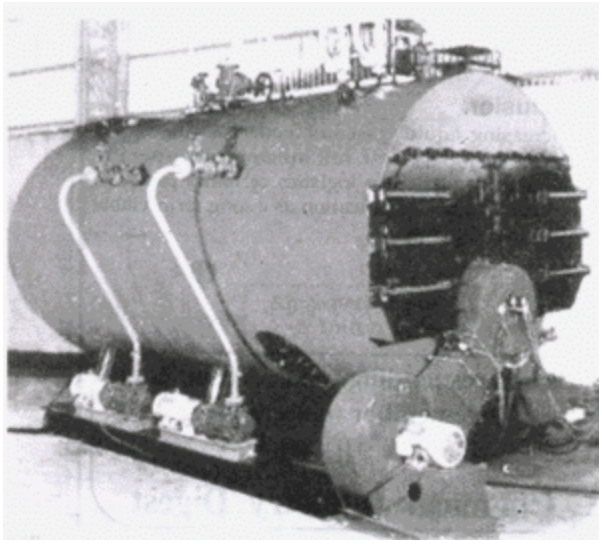
Steam Boiler is a very important equipment for all process industries. There are many codes in use for design of boilers internationally. All these codes mainly take care of safety aspects of boilers from angle of mechanical strength. Some codes stipulate norms for furnace sizing on thermal input basis. Many users who have limited knowledge of boilers tend to believe that any two boilers designed as per same design code are technically at par. This is far from the truth. This article lists out the important selection criteria for boilers.

Introduction

In today's modern world, mechanical strength is only one of the many criteria, which decides the superiority of any boiler. There are many other more important aspects like efficiency, availability round the clock, ease in maintenance, environmental compliance, etc. This article provides guidelines for any boiler user to evaluate various brands of boilers and quantify the strengths/ weaknesses. The evaluation criteria and its importance are explained in brief as under.

Safety and Reliability

Apart from mechanical strength, it is the control logic and instrumentation, which decides safety and reliability of any modern boiler. Some of the important aspects are discussed below.



Number of boiler water level controllers.

Keeping proper water level in the boiler is of paramount importance from boiler safety point of view. This instrument not only maintains necessary operating water level by controlling the water inflow, but also ensures burner stoppage in case of the level falling below safe limit. It is advisable to have two instruments considering the criticality of the function.

Number of fusible plugs

Fusible plug avoids dry running of a boiler by sparging high-pressure water in the furnace when water level goes below the topmost area of radiation heat transfer zone. This is the ultimate safety device, which can save furnace from collapse and rupture due to dry running. It generally consists of three parts where the innermost and outermost parts are held together with 'low melting point alloy metal'. In case of dry running, this part melts creating an opening through which water in the boiler can enter the furnace extinguishing flame. It is advisable to have two fusible plugs.

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Tube overheat controller

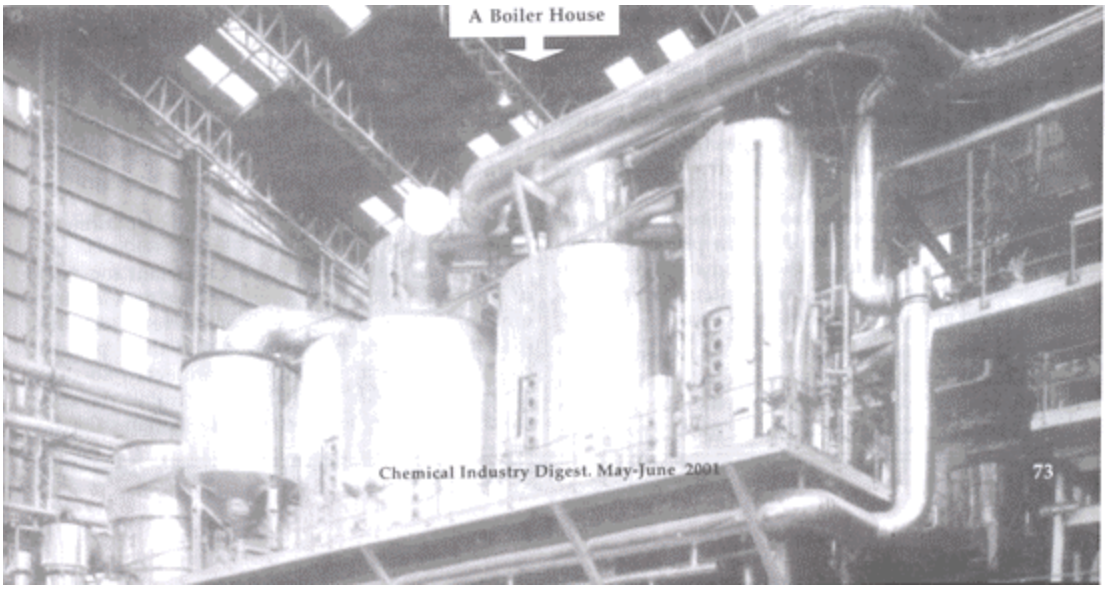
This works as an overriding control in case the water level controller does not function and the burner keeps operating inspite of very low water level. It senses the temp of flue in the topmost row of tube. When the level drops down, this row gets exposed and flue gas temp in these tubes rises much higher than the bulk temp. In such eventuality, this controller sounds an alarm and can also stop the burner depending on the logic.

High stack alarm controller

The stack temp is an indicator of fouling of heat transfer surfaces in the boiler from flue & waterside. This not only results into higher fuel consumption but also overheating of tubes and furnace (in case of waterside fouling). This instrument sounds an alarm in such conditions, cautioning the operator to clean the surfaces.

Sinking time calculation

Sinking time is the time required to lower the water level in the boiler from normal working level to the furnace crown when the feed water pump fails and burner keeps firing at high flame due to failure of all safety devices. The furnace is subjected to very high temperature flame and hence is the most critical component of boiler. In case of dry running the furnaces become the first failure points. Boilers with bottom furnace type design have much higher sinking time than those having furnaces on one side. This gives more time for corrective action in a crisis, thereby avoiding damage to the furnace and possibility of an accident.



Fuel pressure monitoring system

Most of modern oil fired boilers use pressure jet burners. It is necessary to maintain fuel pressure above the minimum desired limit to ensure atomization of fuel and complete combustion. Fuel pressure sensing system should be provided for tripping the burner in case the fuel pressure falls below the safe limit.

Fuel temperature monitoring system

For heavy oil fired boilers, the fuel needs to be heated to reduce viscosity and improve atomization. Low fuel temp can result in incomplete combustion, unstable flame and backfiring. Fuel temp monitoring system should stop the burner firing below safe temp.

Combustion air pressure monitoring system

This will ensure availability of air for combustion. Unavailability/ shortage of air results in similar situations mentioned above. The burner should trip automatically in case in case air is not sufficiently available.

Steam pressure modulation

Steam pressure tends to change due to fluctuations in demand from plant. Immediate correction in fuel firing rate is necessary to maintain steady fuel pressure. Stepless or continuous modulation adjusts the fuel input constantly by checking steam pressure feedback. High-low or step modulation adjusts the fuel in stages. Stepless modulation can maintain steam pressure on the boiler within a tolerance of 0.1 – 0.2 kg/ cm^2. With step or high-low type of modulation, you can expect variation of 1.0 to 1.5 kg/ cm^2. Above is subject to steam demand being lower than boiler capacity at any given time.

Steam pressure limit switch

If the steam demand drops to a very low level, the steam pressure rises in spite of burner firing at minimum possible level. Steam pressure limit switch cuts off the burner and eliminates possibility of safety valve popping up, saving precious fuel.

Safety valves

Safety valves release steam without any need for electronic signal from instruments. This is a very important device and is a must as per all codes. The release capacity should be more than that of the steam generation capacity of boiler.

Automatic blow-down/ Continuous blow-down

Salts in feed water does not evaporate with steam and hence the concentration in boiler keeps on increasing. It is essential to drain the highly concentrated boiler water and add some extra feed water, which has comparatively much lower TDS. Conventionally the operator used to give blow done a periodic intervals in full day. This is done 3 to 6 times a day. In this process the TDS in boiler keeps fluctuating. If the operator delays the blow-down the TDS increases beyond acceptable limits resulting in salts getting deposited on tubes and the furnace. In automatic blow-down steam, the TDS in boiler is sensed constantly and the opening of blow-down valve is adjusted to maintain the TDS of boiler water below desired limits. Anyhow proper care has to be taken while selecting the automatic blow-down system since there are very few systems which have performed in the field without problems.

The automatic systems would be expensive for smaller sizes of boiler. One can always have a continuous blow down system where blow-down valve can be adjusted by calculating the % blow-down required based on boiler load and feed water TDS. It can be adjusted considering full capacity of boiler. A heat recovery system will save the heat going out from boiler due to blow down.

Boiler water TDS meter/ Conductivity meter

Considering importance of the TDS level in the boiler, the boiler water needs to be checked for TDS periodically. Necessary meters should be provided to the operator for this job.

Furnace water TDS meter

TDS of water in the tubes of water walled furnace (mainly for solid fuel fired boiler) is always much higher than the drum. On line separate TDS sensing arrangement can be very useful for such boilers.

Furnace draft alarm for solid fuel boilers

The furnaces of solid fuel fired boilers are kept at a slight negative pressure (on flue side) to avoid flame, hot flue gas coming out from firing doors and the fuel feeding system. Alarm can be provided to provide warning of higher pressure than desired.

Pilot flame ignition

For gaseous fuels pilot flame is essential to ensure flame stability during ignition. It is more so in case of lean gases like Bio-gas. In case of liquid fuels, burner with rotary, steam and air atomization are generally provided with pilot flame ignition.

Electrical panel with Fuses, O/L Relays, ELCBs, Earthings, etc

The electricals are equally important. Panel should be equipped with Fuses and O/L relays for all motors. MCB is necessary for the safety of electrical components. ELCB provides safety to the operating staff.

Instrumentation for measurement of parameters related to safety of a boiler

Some parameters are very important for safety of a boiler. Instruments need to be provided for measurement of these parameters. On-line instruments are preferred since they provide continuous data. Records connected to these instruments create record of data round the clock which can be very useful in trouble shooting. Off-line instruments have to be used by operating staff for periodic monitoring of these parameters. Operator discipline is very crucial for these instruments to be effectively used. Parameters such as feed water TDS, boiler water TDS, boiler water level, steam pressure, stack temperature, and tube overheat temperature are very important.

Environmental Compliance

Environmental aspects are becoming more important day by day. Generally local pollution control boars have limits specified for polluting elements in flue gases. Constituents such as CO, NO_x, particulate matters, SO_2/ SO_3, hydrocarbons, in flue gases should be measured and must be below the limits specified by the pollution control boards.

Following aspects are equally important even though many of them do not get covered under any statutory requirements:

- Boiler water TDS and treatment before disposal.
- No fuel oil spillage/ proper spillage recovery (for oil fired boilers)
- Noise level in boiler house.
- Normal boiler house ambient.
- Proper soot disposal system while tube cleaning and after tube cleaning.
- Ash disposal system (for solid fuel boilers)
- Lighting and illumination in boiler house.
- Fire extinguishers in boiler house
- First aid kit in boiler house.
- Space for operator movement.

Efficiency

Efficiency has becomes the most important factor for selection of boiler considering the rapidly rising fuel prices. Three percent additional efficiency can save as much fuel is one year, which can be equal to the cost of complete boiler. Many old-timers tend to restrict the efficiency to less than 90% level fearing the cold-end corrosion due to sulfur in fuel. If the heat recovery system is designed properly, efficiency upto 95-96% on NCV is possible even on heavy oil.

Chimneys can be protected by anticorrosive coatings to enhance life. If chimney is installed with structural supports, sections of chimney duct can be replaced quickly after using for 10-15 years.

For efficiency measurement, following standards may be used**:**

- BS/ ASTM/ ISI.
- Both direct and indirect methods can be used while providing/ testing the product for acceptance.
- For routing checks, indirect methods may be used.
- PCRA datasheets will be followed/ Accepted for fuel properties.

For monitoring efficiency on regular basis, instrumentation – either on-line or off-line-can be provided to check following parameters:

1. Stack temperature.
2. O_2 in fluegas.
3. Steam flow

4. Water flow
5. Fuel flow
6. Smoke opacity.
7. DP on fluegas across boiler.
8. Blow-down flow rate switch for high and low flow rates.

Availability to user for maintenance without stoppage

Companies without a standby boiler, need to look at this aspect in detail. Facilities for maintenance of components without stoppage of boiler can save the investment of a standby boiler. It is necessary to have facility to carry maintenance work on components like water pump, fuel pump, fuel oil heater, filters for fuel and water, and instruments (viz. –pressure gauge and temperature gauge), without stopping the boiler operation.

Mechanical and manual cleaning convenience

Convenience for cleaning saves time required for preventive maintenance shutdown. Convenience can be categorized in three areas, viz, time, manpower, and efforts. These should be evaluated for both 'water side' and 'flue gas side' of any boiler.

Chemicals cleaning convenience

On some occasions chemical cleaning is required to be done. This eliminates opening of boiler and saves time. Hence provisions for such cleaning should be provided.

Repair convenience

In some designs this aspect is completely neglected. This is very important criterion. If proper care is not taken while designing, repairs can be very expensive and unaffordable. Pressure and non-pressure parts, tubes and furnace should be studied carefully from this point of view.

Operating convenience

If it is inconvenient to carry out certain function for the operator, there is tendency to skip that particular operation, which can result in accidents, or inefficient operation. Visibility of instruments and ease of access for observation are the two important factors aiding operating convenience.

Instrumentation reliability

Providing lot of instrumentation can be counter effective if the instruments are not reliable. The following factors can ensue reliability of instruments:

- Instrument manufacturers certified by Instrument Societies.
- Calibration certificate available.
- Repair convenience.
- Replacement convenience.
- Control panel reliability:

    a) Margins on power ratings of instruments
    b) Dust proof enclosure
    c) Control panel architecture
    d) Maintenance convenience

Trouble shooting logic diagnostics and support

Trouble shooting can be nightmare if lot of interlocks are provided without visual indications on panel. It can become very easy with:

- On-line logic analyzer.
- Data acquisition and control systems.
- Indication for all parameter status.
- Audio/ visual alarms.

Life expectancy

Every purchaser can use his own yardstick for this aspect. Depending on the industry, market conditions and many other factors this can change. But nevertheless it is a very important aspect which needs to be deliberated upon before making a final decision.

Space/ dimensions/ weight

The cost of installation does not involve only boiler. The civil and steel structural requirements, cost of land occupied must be considered while evaluating commercially.

Site start-up time

The investment in boiler can start paying only after the same is commissioned. Amount of site work decides the time required for starting after the boiler reaches site.

Transportability

Transport costs can escalate appreciably if the shape and size of each individual component is such that it is difficult to transport. This is very significant if user is far away from the manufacturer.

Aesthetics

Eventhough this does not help in day to day functioning directly, good aesthetics can have positive psychological effect on operating staff.

External facility dependence

A system design which demands many external facilities result in high initial and running cost. Typically with proper designing of boiler system one can work without such extra facilities like fuel ring main.

Water treatment system simplicity

Different designs of boilers have varying requirements of feed water. A boiler design, which does not demand for very stringent water quality norms, saves initial and running cost.

Conclusion

Steam Boiler selection can be done after evaluating the technical merits on various aspects. Proper selection after detailed study can avoid problems during use of boiler. Boiler being a capital equipment is not procured on routine basis. Hence analysis of all minor and major aspects mentioned above can provide necessary inputs for selection.

Reference Book:
Chemical Industry Digest
(May-June 2001)